Comparison of the differences between H-permutite and Zeolite adsorbent

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ABSTRACT

Zeolite is an aluminosilicate mineral with a three-dimensional framework structure with interconnected cavities and channels, which makes its surface area very large and effective as an adsorbent. There are currently natural and artificial types of zeolites. The high adsorption efficiency of zeolite is used as an adsorbent in all areas of the chemical industry. This scientific work obtained an alternative version of zeolite by synthesizing H-permutite based on natural raw materials. To study the characteristics of the structure of the molecular compounds of the studied samples, the Nicolet iS50 (Thermo Fisher Scientific, USA) IR-Fourier spectrometer was used. Measurements were made in the 4000-400 cm-1 spectral range, with spectral resolution not exceeding 0.1 cm. The test specimen was pressed against the mounting surface with a flat-tip probe. near, mid, and far IR attenuated total internal reflection (ATR) I S50 Analytical indicators were determined using a hole and a diamond crystal for measurement.

Keywords: Zeolite, H-permutite, aluminum trichloride, sodium silicate, ion exchange, pH indicator, waterproofing, bentonite, kaolinite, biotite, vermiculite, glauconite, granule.

Beginning in the early 1940s, scientists at Union Carbide began research on the synthesis of zeolites, and they succeeded in synthesizing pure zeolites A and X in 1950 [1]. The discovery of zeolites in the world began in 1756 with the discovery of Stilbite by a scientist named AF Constedt. Constedt described the peculiarity of this mineral: when heated, it seems to boil because the molecules lose water very quickly. According to these properties, this mineral was given the name zeolite, which comes from two Greek words, zeo, meaning boiling, and stone (Kirk-Othmer, 1981) [2]. It is called a zeolite because it boils and emits steam when heated (Dyer, 1994).

Zeolite is used in the separation and purification of petroleum hydrocarbons, as a catalyst, and in gas purification, drying, and separation of gases (including air), drying of freons, extraction of radioactive elements, and creation of strong vacuums. Zeolite deposits exist in the Russian Federation (Voronezh), Armenia, and Georgia. In Uzbekistan, it is found among silts and opaque clays [3,4].

Table 1. Sodium silicate Liquid index M2.2Be50

Sodium silicate standard	Sodium silicate standard 51 ℃	Test result
Relative density (20 ℃) %	50.0 ～ 52.0	50.7
Composition (Na_2O) %	12.8	13.95
Composition (SiO_2) %	29.2	31.05
Module (M)	2.2 ～ 2.4	2.3

Table 2. Sodium silicate Liquid index M3.3Be38

Sodium silicate standard	The sodium silicate standard is 38 ℃	Test result
Relative density (20 ℃) %	36.0 ～ 38.0	38
Composition (Na_2O) %	≥8.2	8.4
Composition (SiO_2) %	≥26.0	26.64
Module (M)	3.1-3.40	3.27

Table 3. Sodium silicate Liquid index M2.2Be40

Sodium silicate standard	The sodium silicate standard is 40 ℃	Test result
Relative density (20 ℃) %	39.0 ～ 41.0	40.9
Composition (Na_2O) %	≥9.5	39.1 ～ 41.0
Composition (SiO_2) %	≥22.1	≥22.1
Module (M)	2.2 ～ 2.5	2.2 ～ 2.5

Chemical industry: various silicate products such as silica gel, white carbon black, zeolite molecular sieve, sodium metasilicate pentahydrate, silica sol, layered silica, instant powder sodium silicate, potassium sodium silicate, etc. are the main raw materials of silicon compounds. Light industry: Sodium silicate is an indispensable raw material for washing powder, soap, and other detergents, as well as a water softener and coagulant.

Textile Industry: Sodium silicate is used in dyeing, bleaching, and sizing.

Mechanical engineering industry: Sodium silicate is used in casting, grinding wheel production, metal preservatives, etc. Construction industry: Sodium silicate can be used to produce quick-drying cement, acid-resistant cement, waterproofing oil, soil treatment agents, refractory materials, etc.

Agriculture: Sodium silicate is used in silicon fertilizers. In addition, sodium silicate oil, soap filler, corrugated paper adhesive, laboratory crucible and other high-temperature resistant materials, metal preservatives, water softeners, detergent additives, refractory materials, and catalytic cracking of ceramic raw materials are used as a silica-aluminum catalyst for materials, textile bleaching, dyeing and pulping, mine beneficiation, waterproofing, corks, wood fire prevention, food preservation and adhesive production, etc.

Table 4. Molecular mass ratio of zeolite

Element	Symbol	Atomic mass	atomic num.	Mass percentage
Natriy	Na	22.9898 g/mol	1	100%
My cream	Si	28.0855 g/mol	1	100%
Kislorod	O	31.9988 g/mol	2	100%

In the research on sorbents, the authors [5]. used different materials and researched their sorption properties. Peat and sawdust-based sorbents have been proposed for softening technical waters in oil processing. Also, wood shavings containing cellulose have been recommended as a chemical reductant for the treatment of industrial wastewater containing some heavy metals produced in galvanic plants because of cellulose-containing functional groups [6].

Bentonite, kaolinite, biotite, vermiculite, and glauconite recycled sorbents in various ways are effective and promising in softening industrial technical water and removing heavy metals because their natural resources are sufficient in our republic [7]. In addition, these minerals are relatively cheap, their deposits are widely distributed throughout the territory of our republic, their reserves have been studied, and their operational characteristics are high.

Adsorption properties of natural minerals are explained by their chemical and mineralogical structure, crystal structure, and dispersion of particles. The main components of natural minerals are SiO_2 (30-70 %), Al_2O_3 (10-40 %), and H_20 (5-10 %); their relative surfaces are up to 500 m^2/g. Zeolites are used more often than permutates from mineral substances and synthetically obtained adsorbents because they have selective absorption properties.

Permutites and zeolites consist of layered aluminosilicates $[SiO_4]_4$ and $[AlO_4]_5$, crystal lattices are tetrahedral. The microstructure of these adsorbents comprises layered channels, which facilitate the free movement of water molecules and cations, thereby improving their adsorption and ion-exchange properties. Zeolites exchange their cation (Ca^{2+}, Na^+, K^+, Mg^{2+}, etc.) with pollutant cations in wastewater or waste solutions, while they have the ability to selectively absorb.

To increase the sorption properties of zeolites, they are chemically modified with 3% chitosan solution or ferro ferricyanide complexes. In the process of obtaining the proposed H-permutite, this step is not performed. Despite the great demand for natural zeolites, the process of their application is not free from shortcomings, because the cracks in their crystal structure have certain sizes, and only small-sized ions can enter the space. In some processes, the sorption pores are not filled because the absorbed ions are relatively large. In addition, the ion exchange process is directly dependent on temperature, which limits the use of ultra-in-water treatment technologies.

Synthetic zeolites are free of these defects and are widely used in industry, but their use in water purification processes is not justified due to their relatively high cost and the complexity of regeneration processes. Therefore, it is urgent to use new types of adsorbents for cleaning technical or industrial wastewater, preparing them for use in boiler houses[8].

As mentioned above, the treatment of industrial wastewater contaminated with various organic and inorganic substances, and the softening of technical water for reuse, are relatively expensive processes. The reason for this is that most of the adsorbents used in the cleaning process are imported, and the regeneration processes are complicated [9]. Taking this into account, research was conducted on obtaining aluminosilicate adsorbent with a layered structure, that is, H-permutite. H-permutite softens technical water up to the established requirements and is very effective in obtaining circulating water for boilers, where the softened water is not contaminated with Na^+ ions, as in the case of Na-permutite application.

Various mineral and artificial adsorbents, including Na-permutite, are used in industry for wastewater treatment and softening of technical waters. When Na-permutite is used for water softening, the calcium and magnesium ions in the water are softened due to the exchange of equivalent amounts of sodium ions. In this case, the water is cooled, free of calcium and magnesium ions, which give hardness, but its mineralization remains unchanged due to sodium ions, which do not give hardness properties [10,11]. If H-permutite is applied to this process, the mineralization of water decreases, the efficiency of steam boilers increases dramatically, and especially the efficiency of high-pressure steam boilers improves, and the useful work coefficient increases dramatically.

From the results of the conducted experiments, it became clear that the efficiency was the highest when the amount of $Na_2SiO_3 \cdot 9H_2O$ was 23 g, and the amount of $AlCl_3$ was 3.5 g in the synthesis process, and it was 54%. To synthesize H-permutite in optimal proportions, 23.0 grams of $Na_2SiO_3 \cdot 9H_2O$ were dissolved in 1 l of distilled water at room temperature, and 3.5 g of $AlCl_3$ were also dissolved in 1 l of distilled water and mixed for 10 minutes. In this case, the process proceeds according to the following equation in aqueous medium at room temperature:

$$2AlCl_3 + 3Na_2SiO_3 9H_2O + H_2O = Na_2Al_2Si_2O_8\downarrow \cdot nN_2O + 6NaCl + SiO_2$$

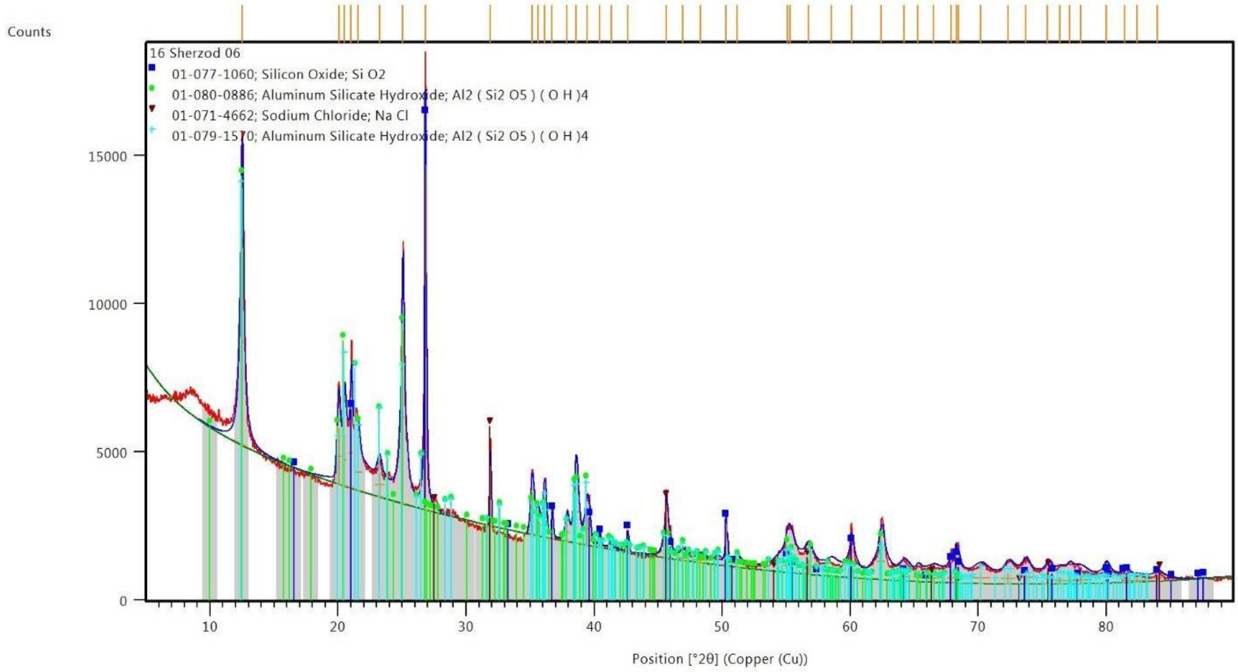
The formed $Na_2Al_2Si_2O_8$ reacts with added $CaNCO_3$ to form $Ca_2Al_2Si_2O_8$. After treatment with 5% HCl, $H_2Al_2Si_2O_8$ (H-permutite) is formed and precipitates, while NaCl and SiO_2 ions remain in solution. The precipitate was filtered and dried to constant weight at 120 °C, and the efficiency was determined. The weight of our obtained product was 19.6 g, and the efficiency of the process was 74%. A sample of 2.2 kg of H-permutite was taken under optimal conditions determined by this technology. Navbakhor mine bentonite was added to the obtained sample in the amount of 5% as a plasticizer and granulated. To determine the amount of water needed for granulation, samples with different amounts of water added to the mixture were prepared and tested (Table 5).

Table 5. Required for the granulation of H-permutite, determine the amount of water

t/r No	Sample	Moisture, %	Water content, %	Result
1	$H_2Al_2Si_2O_8$	4	19	The granules are broken, emulsifying
2	$H_2Al_2Si_2O_8$	4	20	The bulk of the granules are whole, emulsifiable
3	$H_2Al_2Si_2O_8$	4	21	The granules are whole, the consistency is sufficient
4	$H_2Al_2Si_2O_8$	4	22	The granules are whole, slightly sticky due to moisture
5	$H_2Al_2Si_2O_8$	4	23	Granules are partially deformed, sticky
6	$H_2Al_2Si_2O_8$	4	24	The shape of the granules is distorted, the shape is variable

Table 5 shows that when we added 5% bentonite and 21% water to a sample with a moisture content of 4%, a mixture with optimal moisture content for granulation was obtained. The prepared mixture was granulated in an FSH-0.004M laboratory granulator with a 3.0 mm diameter. The prepared granules were dried for 1 hour at a temperature of 180^0C with periodic mixing. The dried granules were sieved through laboratory sieves, and the fraction between 1 and 3 mm was separated. This fraction was 92 %. The obtained product was placed in a sorption column with a diameter of 50 mm and a height of 200 mm.

Measurement of the phase characteristics of the studied samples by an X-ray diffractometer was carried out on a Panalitik Empyrean powder X-ray diffractometer. All monitoring of equipment performance was performed by computer using Data Collector software and X-ray diffraction pattern analysis software [12]. Measurements were taken at room temperature in a 2-angle range, 5° to 90° stepwise scan mode with 0.013 (2-Main Graphics, Analyze View: 2-Sample X-ray Analysis) degree step



and signal at 5 s point was done with the collection time and IK. To study the characteristics of the structure of the molecular compounds of the studied samples, the Nicolet iS50 (Thermo Fisher Scientific, AQS H) IR-Fourier spectrometer was used. Measurements were made in the 4000-400 cm-1 spectral range, with spectral resolution not exceeding 0.1 cm. The test specimen was pressed against the mounting surface with a flat-tip probe. The following analysis values were determined using a pinhole and diamond crystal to measure near, mid, and far IR attenuated total internal reflection (ATR) at IS50.

Figure 1. X-ray analysis of zeolite brand A.

If the water is hard (the total amount of calcium and magnesium salts in its content is higher than normal), it is softened. Groundwater is often de-ironed (enriched with air oxygen) by aeration. Lime, sodium aluminate $NaAlO_2$, and sometimes burnt dolomite are used for water desilicification (reducing the amount of metasilicic acid $NaSiO_3$ and its salts). To remove other dissolved salts in the water, it is sweetened or desalinated with ions. Water is degassed to remove hydrogen sulfide, methane, radon, carbon dioxide, and other dissolved gases.

After that, the resulting product, namely hydrogen permutite precipitates, NaCl, and SiO_2 remain in solution. The product is filtered, washed, dried at a temperature of 110 ^{0}C to a constant weight, and the yield of the product is determined. In our case, the dried product was 14.3 grams, and its yield was 53%. Using this technology, a sample of 1.1 kg of hydrogen permutite was obtained. The resulting product is granulated, for which 8% enriched bentonite from the Navbahor mine is added as a plasticizer. Water was added to the pre-determined optimal amount of granulation, which was 21%, and water was added in a FSH-004 laboratory granulator with a screw hole diameter of 1.0 mm. The finished granules were dried at a temperature of 175^0 C, stirring from time to time. The dried granules were sieved, 1-3 mm fractions were sorted to study the sorption properties. We saw that the x-ray analysis of the obtained sorbent (Fig. 2) is proportional to the x-ray analysis of zeolite.

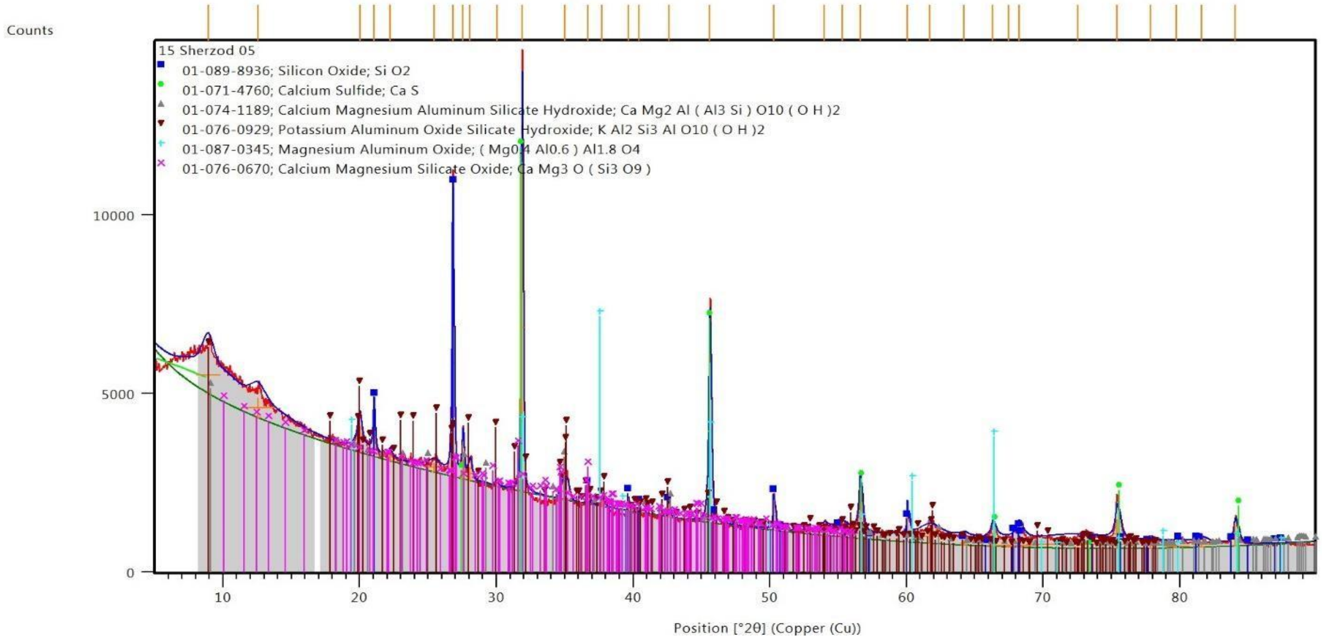


Figure 2. X-ray analysis of H-permutite.

Zeolite, as an ion exchanger, can exchange with other ions in the surrounding solution. With this property, zeolite-A with Na^+ ions can be used as a water softener, where Na^+ ions replace Ca^{2+} ions from hard water. Zeolite saturated with Ca^{2+} can be renewed by dissolving it in a pure Na^+ or K^+ salt solution. Zeolite-A is now added to detergents as a water softener to replace polyphosphates, which can cause environmental damage. Production of potable water from seawater using a mixture of Ag and Ba zeolite is a good desalination process, although the process is relatively expensive [13].

Comparison of Si and Al from zeolites describes the function of their cation exchange capacity. Data from XRF analysis shows that the percentage comparison between SiO2 and Al_2O_3 is relatively smaller, namely 5.56. This comparison theoretically shows that the capacity of the cations is relatively large. These results were obtained in Natural zeolite that has been processed using acid.

HCl reacts with zeolite to extract Al from the zeolite. This resulted in decreasing the Al content in the zeolite so that the ratio of Si/Al moles increases. Metal content, such as Ca and Mg, in zeolite decreased after treatment due to ion exchange between cations from zeolite with protons from HCl. Analysis results using XRF show that the acid treatment process (HCl_5 M) on the catalyst causes a decrease in Ca and Mg metal content in zeolites and an increase in zeolite acidity. Chemical activation carried out by acidification with the aim of agar dealumination occurs. The purpose of dealumination is to optimize aluminum content in zeolite, so that the zeolite becomes more stable at high temperatures, controlling acidity and zeolite selectivity. Dealumination is a process of destruction of the zeolite framework structure that occurs as the disconnection of Al in the framework (Al framework) becomes Al outside the framework (Al non-framework). As a result, the Si/Al ratio will increase.[14]

However, all these materials are characterized by a small ion exchange capacity, different designs of ion filters have been proposed and put into use, and they all have a parallel flow (purified water and regeneration solution flow in the filter in the same direction - from top to bottom). The results of our studies showed that we can achieve economic efficiency if we clean technical water and boiler water using H-permutite. It was found that the cost of generating H-permutite is much lower compared to other adsorbents. We can achieve economic efficiency by producing mineral-rich plant fertilizer from spent H-permutite.

At high pH, the surface of reactive dyes will increase positively charged cations through attractive electrostatic forces. Increasing alkalinity causes the adsorbent layer to change from positive to negative, therefore, it can reduce the adsorption capacity. Scientific research scientific news of the following consists of :

- H - permutite synthesis in the process raw items ratio big role plays in this components the ratio of Na_2SiO_3: $AlCl_3$ is 6:1 when process product the most efficient it happened and output is 74% organize did;
- synthesis Na-permutite when $AlCl_3$ is used in the process harvest to be processed decreased, in a decrease in the amount of Na^+ ions main part Cl^- ions bind to the solution passed and in the sediment H - permutite left;
- technician the water H - permutite with the help of when cleaned of water ion replacement to account for mineralization, sharp decrease and high-pressure working warm up their stomachs, prevention cleaning of the process decrease to account useful work coefficient sharp brought;
- H-permutite studies as a result determined component proportions and another optimal parameter based on high exit with synthesis to do technology.

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